CLAIMS

1. A direct injection fuel delivery system for a motor vehicle comprising:

a pump having an inlet connected to a fuel supply and an outlet at which the liquid fuel is supplied at a pressure of at least 50 bar;

a common fuel rail coupled to the outlet of the pump;

at least one fuel injector nozzle connected to the common fuel rail; and

a flow control valve connected between the inlet and the outlet of the pump to selectively provide a fluid path there between, the flow control valve comprising:

(a) a valve stem having a bore with a valve seat at one end and having an inlet port that opens into the bore, wherein the inlet of the pump communicates with the one end of the bore and the outlet of the pump communicates with the inlet port,

(b) a valve element within the bore and selectively engaging the valve seat to control flow of fluid between the inlet and the outlet of the pump, wherein the valve element has an exterior groove in communication with the inlet port, the exterior groove having first surface proximate to the valve seat and a second surface remote from the valve seat, wherein the first surface is larger than the second surface so that pressure in the groove tends to move the valve element away from the valve seat, and

(c) a solenoid actuator operatively coupled to the valve element so that activation of the solenoid actuator moves the valve element toward the valve seat.

2. The control valve as recited in claim 1 wherein the solenoid actuator comprises an electrical coil and an armature which is operatively coupled to move the valve element toward the valve seat in response to an electromagnetic field produced by the electrical coil.

3. The control valve as recited in claim 2 wherein the electrical coil has an inductance that is less than 3.0 mH and a resistance that is less than 1.0 Ohm.

4. The control valve as recited in claim 2 wherein the solenoid actuator comprises a pole piece fabricated from a soft magnetic composite material and about which the electrical coil is wound.

5. The control valve as recited in claim 4 wherein the solenoid actuator comprises magnetically conductive, disk-shaped armature adjacent the pole piece.

6. The control valve as recited in claim 1 further comprising a seal between the valve stem and the valve element to prevent fuel in the bore from flowing to the solenoid actuator.

7. The control valve as recited in claim 1 further comprising a spring biasing the valve element away from the valve seat.

8. The control valve as recited in claim 1 further comprising an enclosure having a base with an aperture through which the valve stem extends, and a cap extending around the solenoid actuator and sealed to the base.

9. A direct injection fuel delivery system for a motor vehicle comprising:

a supply line carrying a liquid fuel;

a pump having an inlet connected to the supply line and an outlet;

a common fuel rail coupled to the outlet of the pump;

a plurality of fuel injector nozzles coupled to the common fuel rail; and

a flow control valve connected between the inlet and the outlet of the pump to selectively provide a fluid path there between, the flow control valve comprising:

(a) a valve stem having a bore with a valve seat at one end and having an inlet port that opens into the bore, wherein the inlet of the pump communicates with the one end of the bore and the outlet of the pump communicates with the inlet port,

(b) a valve element within the bore and selectively engaging the valve seat to control flow of fluid between the inlet and the outlet of the pump, wherein greater pressure in the bore than at the inlet of the pump tends to move the valve element away from the valve seat, and

(c) a solenoid actuator having an electrical coil and a armature having a disk shape, wherein the armature is operatively coupled to move the valve element toward the valve seat in response to an electromagnetic field produced by the electrical coil, the a solenoid actuator including a spring engaging the armature to bias the valve element away from the valve seat.

10. The control valve as recited in claim 9 wherein the electrical coil has an inductance that is less than 3.0 mH and a resistance that is less than 1.0 Ohm.

11. The control valve as recited in claim 9 wherein the solenoid actuator comprises a pole piece fabricated from a soft magnetic composite material and having an annular groove with in which the electrical coil is wound.

12. The control valve as recited in claim 11 wherein the solenoid actuator comprises magnetically conductive, disk-shaped armature adjacent the pole piece.

13. The control valve as recited in claim 9 further comprising a seal between the valve stem and the valve element to prevent the liquid in the bore from flowing to the solenoid actuator.

14. The control valve as recited in claim 9 further comprising an enclosure having a base with an aperture through which the valve stem extends, and a cap extending around the solenoid actuator and sealed to the base.